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Philips Technical Review

DEALING WITH TECHNICAL PROBLEMS
RELATING TO THE PRODUCTS, PROCESSES AND INVESTIGATIONS OF
THE PHILIPS INDUSTRIES

THE PORT OF ROTTERDAM RADAR SYSTEM

621.396.967

Seven radar stations spaced along the thirty odd kilometres of the Nieuwe Waterweg, a channel running from Rotterdam to the North Sea, were put into operation on the 30th November 1956. On 1st January 1958, after trials for establishing operational procedures and familiarizing personnel with the routine, the service was made available to shipping. The installation has enhanced the efficiency of the port of Rotterdam considerably. Ships can now be guided along the waterway in conditions of visibility such as would formerly have paralysed all movement.

The radar service was called upon for assistance as long ago as July 1957, before it had officially come into operation. The 30 000 ton Nieuw-Amsterdam had entered the Nieuwe Waterweg under excellent weather conditions, but halfway between the Hook of Holland and Rotterdam she ran into a fogbank that had suddenly formed. With the radar assistance the ship was able to reach harbour safely.

Port radar as an aid to navigation was not new in 1956. The port of Liverpool has been equipped with a shore radar station since 1948, and an installation at IJmuiden has been in operation since 1951 [1]). At Rotterdam, however, the situation is much more complicated, because ships are continually obliged to alter course on the winding tidal river. The Rotterdam port authorities had applied for advice on the technical aspects of

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[1]) A short description of Philips harbour radar equipment, type SHR 101, Comm. News **13**, 147-148, 1953.
Radar station at IJmuiden (Holland), Philips tech. Rev. **14**, 95, 1952/53.

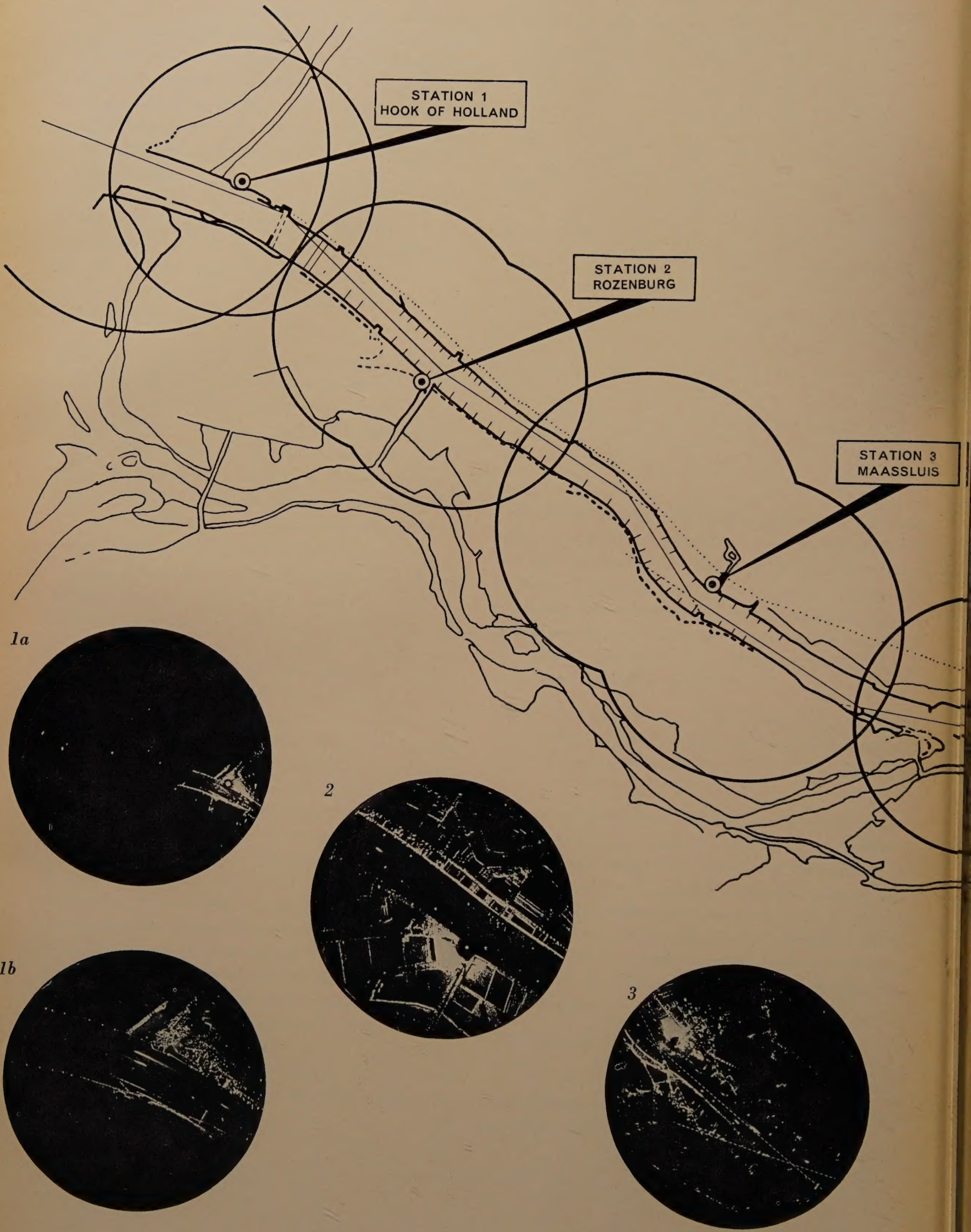
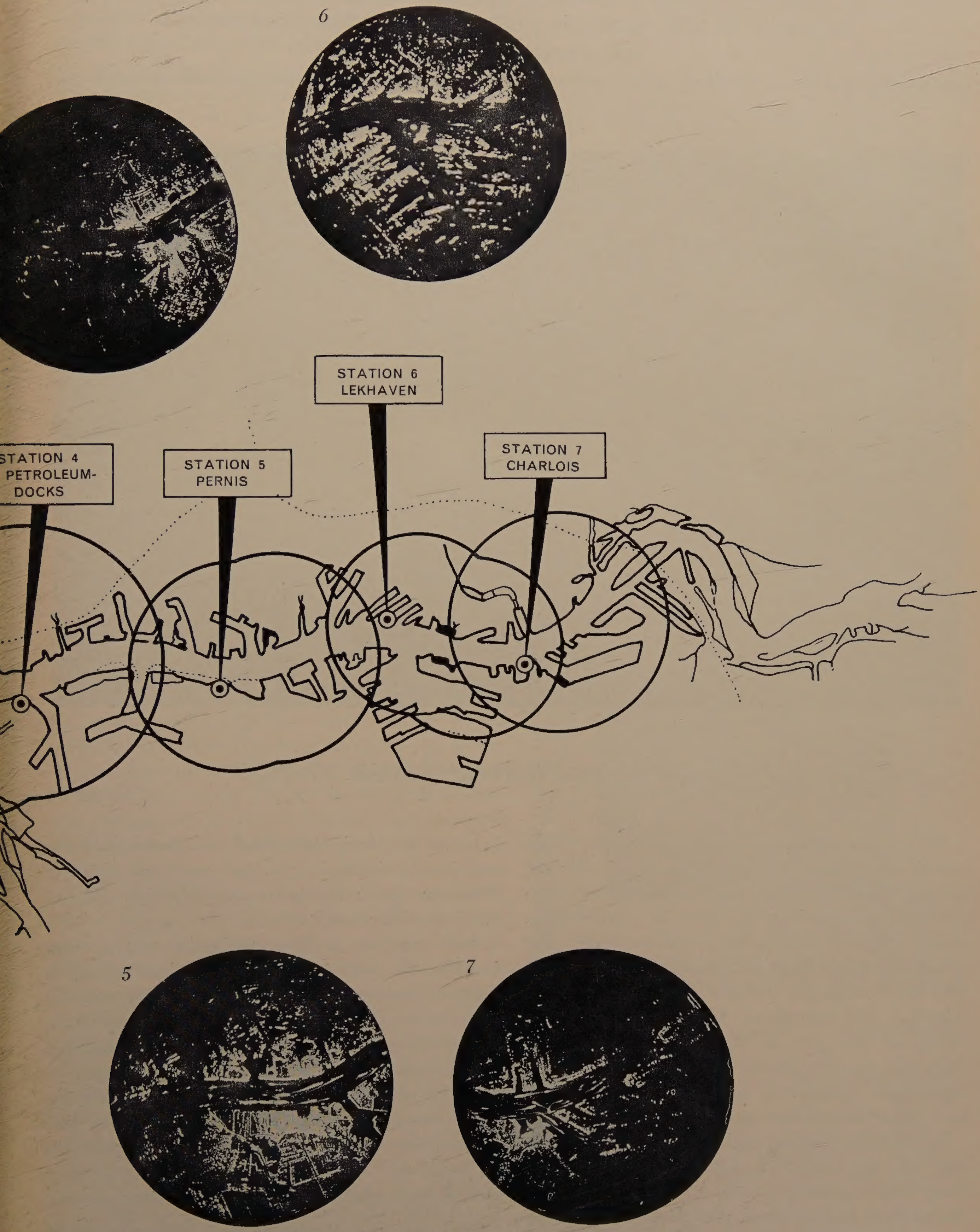

STATION 1
HOOK OF HOLLAND
STATION 2
ROZENBURG
STATION 3
MAASSLUIS
1a
1b
2
3

Fig. 1. Map of the Nieuwe Waterweg, which connects the Hook of Holland with Rotterdam, showing the seven radar stations and the areas normally scanned by each. Displays appearing on one of the two screens of each station are also shown.



the problem to the Netherlands Radar Research Establishment at Noordwijk-on-Sea. In 1953, after extensive tests with mobile radar posts, a final report was drawn up which contained full technical specifications for suitable radar equipment, working on wavelengths in the 3 cm band. The N.V. Philips' Telecommunicatie-Industrie at Hilversum were entrusted with the development and delivery of equipment in accordance with the specifications, part of the apparatus developed by Philips being manufactured by the N.V. Van der Heem in The Hague. A brief description of this radar installation [2]) now follows.

It will be seen from the map in *fig. 1* that the seven stations sweep the whole of the Nieuwe Waterweg plus the Rotterdam harbour area, Station *1* at the Hook of Holland also covering the sea approaches to the Waterweg. In normal circumstances shipping proceeding along the Nieuwe Waterweg follows "leading-lines", as is the case in many inland waterways; these are lines connecting fixed beacons that are illuminated at night. The leading-lines of the Nieuwe Waterweg are shown in fig. 1.

If because of fog or for some other reason visibility becomes so bad that the beacons (and other landmarks) cease to be visible, it is the business of the radar service to provide pilots with the information they require. A pilot will want to know the distance of the ship from a certain leading-line and its distance from and bearing with respect to features such as harbour entrances, the points where successive leading-lines intersect, and so on. The employment of the "Raplot" system developed by the Netherlands Radar Research Establishment allows information of this kind to be supplied with a high degree of accuracy.

Under this system it is possible to superimpose on the P.P.I. display (Plan Position Indicator) one of two kinds of reference lines. This puts the operator in a position to supply the ship directly with data about its position in relation to features relevant to navigation — the entrance to the harbour at the Hook of Holland, for example.

Both kinds of reference lines are generated electronically, and the operator can place their origins anywhere within a circle concentric with the screen and having two-thirds the screen radius. One of the reference lines is a "cursor line"; the echo of some prominent fixed point is chosen as the origin for the cursor line. By turning a knob, the operator can rotate the cursor line about this origin and, with the aid of a second knob, move an electronic marker along it. Having brought the marker

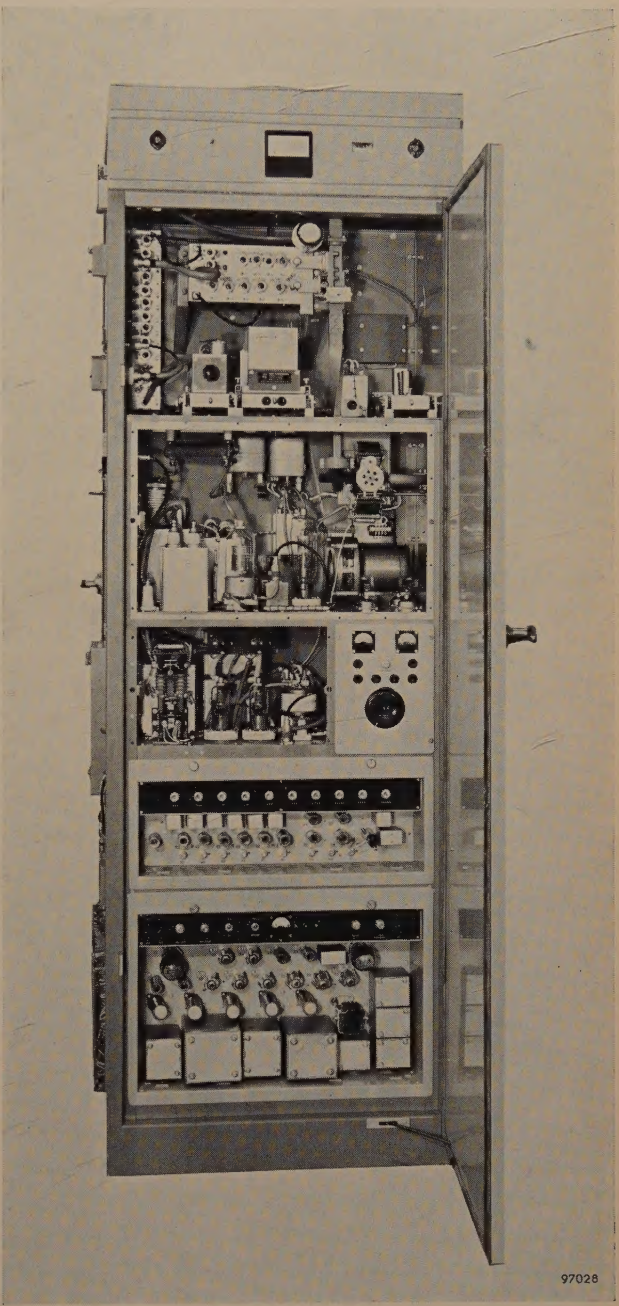


Fig. 2. Radar transceiver in standard cabinet. Technical data:

Modulator/transmitter:	
Local oscillator	tunable magnetron, type 2 J 51
Frequency range	8.9 to 9.2 Gc/s
Maximum power in pulse	approx. 30 kW
Pulse duration	approx. 0.1 microsecond
Repetition frequency	2777 pulses per second (crystal-controlled)
Receiver:	
Intermediate frequency	30 Mc/s
Intermediate-frequency bandwidth	18 Mc/s at −3 dB level
Adjustment of klystron frequency	manual or automatic

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[2]) A more detailed description may be found in B. H. G. Prins and J. M. G. Seppen, The Rotterdam harbour radar system, Philips Telecomm. Rev. **20**, 16-30, 1958 (No. 1).

into position on the echo of a given object (the ship), he can read off on the knob dials the bearing and distance of the object with respect to the chosen origin of the cursor line. All this takes no more than a few seconds. The readings are equally accurate for an eccentric and a centric display (see below).

The other kind of reference lines are fixed lines which may, for example, represent the leading-lines referred to above or the central axis of a harbour entrance. They allow the radar operator to supply ships with information closely corresponding to that used in normal navigation. These lines appear on the screen as a chain of short dashes enabling distances to be estimated quickly and accurately, the length of one dash plus one interval being equivalent to 100 m. Examples of these broken reference lines may be seen in the screen display under Station *3* in fig. 1; in this particular case they represent leading-lines.

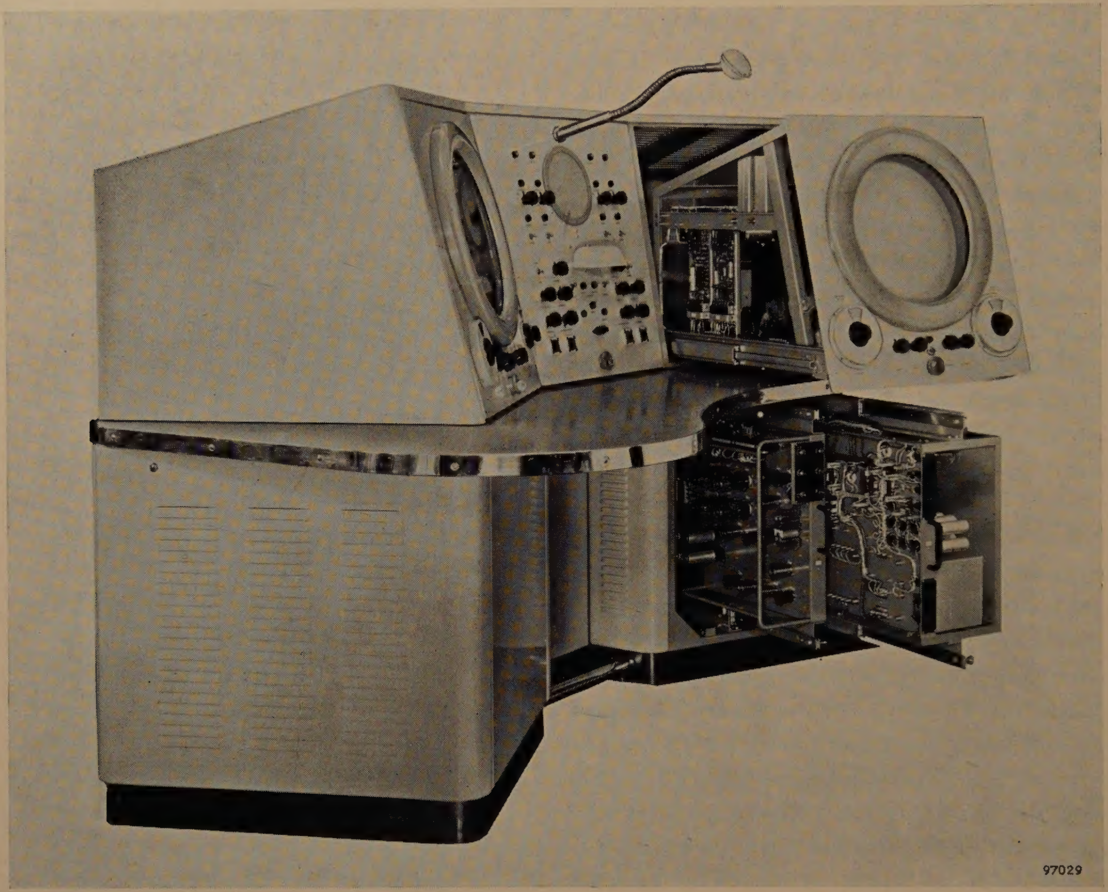

Fig. 3. A control desk with two P.P.I. screens (diam. 38 cm). All units comprising the equipment slide forward for inspection.

Distances between the ship and points on the screen can be determined down to 20 m plus 0.5% of the value indicated. Bearings are given with an error of less than 0.5°.

As will be seen from fig. 1, the ground covered by most of the stations consists of two overlapping circular areas. At the stations themselves there is a control desk with two P.P.I. screens, on each of which one of the circular areas is displayed. Since the station is not located at the centre of either circle, some means must be available for providing an eccentric displacement of the displayed picture. This is done by passing adjustable bias currents through the scanning coils of the cathode-ray tubes. It is possible in this way to adjust eccentricity in any desired direction up to a maximum displacement of two-thirds the screen radius.

The scale of the display on each screen is adjustable, allowing a larger or smaller area to be covered as desired. At Stations *2* to *7* inclusive, coverage is continuously adjustable from a circular area of radius 2000 m to one of radius 5000 m. In normal circumstances both screens at each station display the smallest areas, all of these together giving coverage for the whole of the Waterweg, as in fig. 1. The areas covered by individual stations can be enlarged in such a way as to restore complete coverage if one station goes out of action.

If a breakdown disrupts one of the displays, the other screen is switched over from small-area to large-area coverage and simultaneously recentred. In this way the whole of the area to be covered by the station is again visible. Normally two screens are in use, therefore, but each serves as a standby for the other. The radar transceivers themselves are duplicated, likewise to ensure continuity of the service.

In the Hook of Holland station there are two control desks instead of one, each having two screens (see *title photograph*). One desk covers the estuary and the port entrance, the other the approach area and a sea area extending beyond the cruising stations of the two pilot vessels. The radii of the circular areas appearing on the four screens can be adjusted as follows:

Desk 1	screen 1:	5000-7500 m and 2000-5000 m
	screen 2:	2000-5000 m and 2000-5000 m
Desk 2	screen 1:	5000-7500 m and 2000-5000 m
	screen 2:	5000-7500 m and 12 000-16 000 m.

A further feature of the Rotterdam radar service is that pilots are supplied with small transceivers enabling them to maintain contact with the radar stations by radiotelephony. The seven radar stations have their own transmitting and receiving frequencies in the 160 Mc/s band. As the ship proceeds up the Nieuwe Waterweg, the pilot is passed on from one station to the next.

Fig. 2 shows a radar transceiver built into a standardized steel cabinet. A control desk with two P.P.I. screens (diam. 38 cm) is shown in *fig. 3*. Some technical details are given in the captions to the photographs.

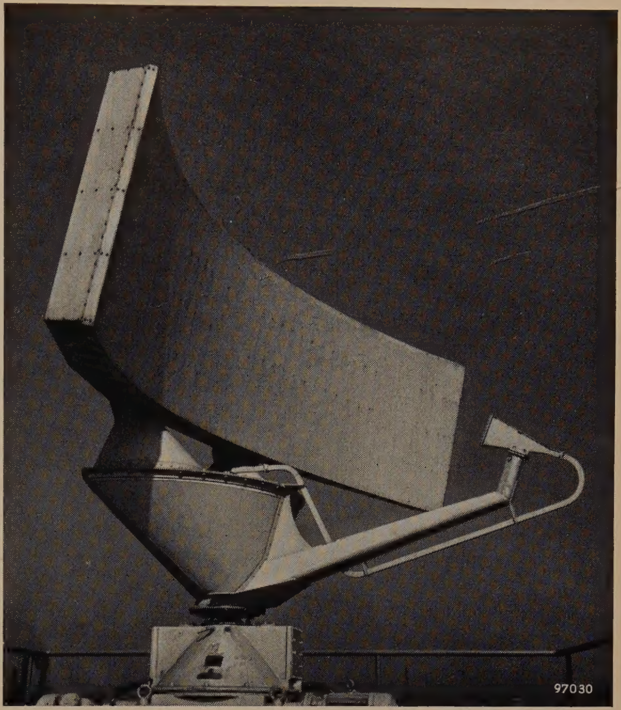

Fig. 4. Rotating aerial assembly used in the Rotterdam radar system.

The aerials, one of which is shown in *fig. 4*, are cylindrically parabolic in shape and make 18 revolutions per minute. The beam radiated has a main lobe with a 3 dB width of 0.7° in the horizontal plane and of about 17° in the vertical plane (these figures thus refer to the angles at which the radiation is 3 dB weaker than in the axial direction). In the side lobes of the radiation pattern the field is at least 27 dB weaker than in the main lobe.

B. H. G. PRINS *) and J. M. G. SEPPEN *).

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*) N.V. Philips' Telecommunicatie-Industrie, Hilversum.

TOPOTACTICALLY CRYSTAL-ORIENTED FERROMAGNETICS

538.221:621.318

In recent years a group of compounds possessing hexagonal crystal structure has been added to the ceramic magnetic materials. They are compounds of Fe_2O_3 with BaO and MeO (Me represents one of the divalent metals Mn, Fe, Co, Ni, Zn or Mg). The individual crystals of many of these compounds exhibit marked magnetic anisotropy; in some the magnetization shows a strong preference for orientation in the direction of the *c*-axis (the hexagonal axis), in other compounds the preference is for an arbitrary direction perpendicular to the *c*-axis. In the first case the material is said to have a preferred *direction* of magnetization, in the second case a preferred *plane*. Materials of the first kind are particularly suitable for making permanent magnets (one example is ferroxdure [1])). Materials of the second kind are magnetically soft and particularly suitable for use at high frequencies (one example is ferroxplana [2]), suitable for frequencies up to about 1000 Mc/s).

To derive full benefit from the magnetic anisotropy it is desirable in both cases that the *c*-axes of the crystallites in the polycrystalline material, obtained by sintering, should all be parallel. Such a "crystal-oriented" material — which thus possesses a texture — shows the same magnetic anisotropy as its constituent crystallites; the sintered non-oriented material, on the other hand, is isotropic. The advantage of crystal-orientation is evident from the fact that the $(BH)_{\max}$ product of crystal-oriented ferroxdure, for example, can be about 3.5 times higher than that of non-oriented ferroxdure [3]). In the case of ferroxplana, crystal-orientation can make the permeability about 3 times as large [4]).

At the Research Laboratories at Eindhoven a new method for making these crystal-oriented materials has been evolved. Before describing it, we shall give a brief outline of the method used hitherto [5]).

A powder of the material to be oriented, so fine that each grain consists of one crystal, is mixed with a liquid. A paste or thick suspension is thus produced in which the crystals are easily able to rotate. To align crystals that have a preferred *direction*, the suspension is introduced into a static magnetic field; for preferred-*plane* orientation a rotating field is used (*fig. 1a* and *b*). The crystal-orientation so obtained is made fast by compressing the suspension into a pellet of the desired form. Upon subsequent firing for a few hours at 1100 to 1300 °C the crystals become sintered together, in which process the orientation is preserved and sometimes even improved.

We shall discuss the new method with the aid of an example. From a suspension consisting of a mixture (not a compound) of 1 mole $BaFe_{12}O_{19}$ (ferroxdure), 2 mole CoO and 2 mole Fe_2O_3, a pellet is pressed whilst a static magnetic field is applied. This causes the alignment of the strongly anisotropic ferroxdure crystals, but not of the non-magnetic CoO and Fe_2O_3 crystals. When the pellet is fired for some hours at 1250 °C, the following reaction takes place:

$$BaFe_{12}O_{19}\uparrow + 2CoO + 2Fe_2O_3 \rightarrow BaCo_2Fe_{16}O_{27}\perp .$$

(The signs $\uparrow$ and $\perp$ indicate respectively a preferred direction and a preferred plane.) In this way we obtain a sintered aggregate of hexagonal crystals of the compound $BaCo_2Fe_{16}O_{27}$. The important thing is that the *c*-axes of these new crystals show the

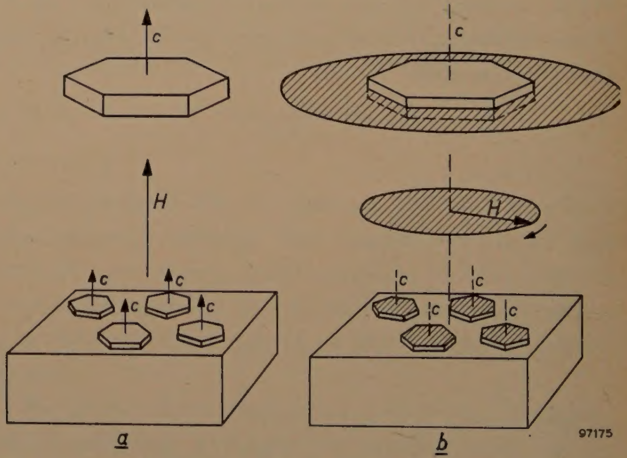

Fig. 1. Method of orienting the grains of hexagonal ceramic magnetic materials by means of a magnetic field. Each grain consists of one crystal in the form of a platelet. In (*a*) the *c*-axis (hexagonal axis), which is perpendicular to the platelet, is a preferred direction of magnetization. When a static magnetic field *H* is applied, the *c*-axes align themselves parallel with this field. In (*b*) the plane perpendicular to the *c*-axis is a preferred plane of magnetization. In this case, when a rotating field is applied, the *c*-axes align themselves perpendicular to the plane in which the field rotates.

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[1]) J. J. Went, G. W. Rathenau, E. W. Gorter and G. W. van Oosterhout, Ferroxdure, a class of new permanent-magnet materials, Philips tech. Rev. **13**, 194-208, 1951/52.

[2]) G. H. Jonker, H. P. J. Wijn and P. B. Braun, Ferroxplana, hexagonal ferromagnetic iron-oxide compounds for very high frequencies, Philips tech. Rev. **18**, 145-154, 1956/57.

[3]) A. L. Stuijts, G. W. Rathenau and G. H. Weber, Ferroxdure II and III, anisotropic permanent-magnet materials, Philips tech. Rev. **16**, 141-147, 1954/55.

[4]) A. L. Stuijts and H. P. J. Wijn, Crystal-oriented ferroxplana, Philips tech. Rev. **19**, 209-217, 1957/58.

[5]) See also articles [3]) and [4]).

same orientation as the *c*-axes of the ferroxdure crystals, which disappeared during the reaction (*fig. 2*). We thus have the phenomenon that in a chemical reaction between solids the crystal-orientation of the reaction product is correlated with that of one of the initial substances [6]). To denote this phenomenon we have coined the term *topotaxy* [7]).

The fact that a topotactical reaction can indeed produce a well-oriented product is shown by X-ray diffraction patterns such as that in *fig. 3*. Not all topotactical reactions are as favourable as this however; there are examples in which the end product shows a poor orientation. The results will shortly be published of an investigation into the various factors that determine whether the end product of a topotactical reaction will be well-oriented or not.

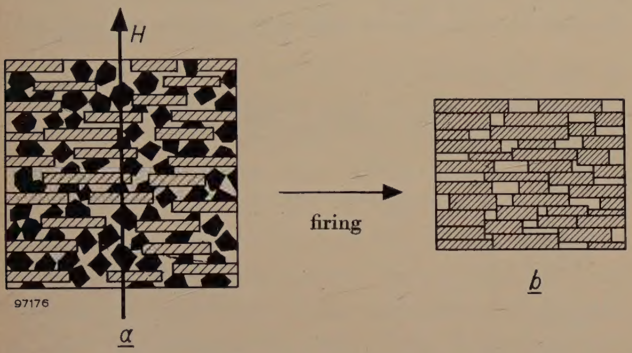

Fig. 2. Crystal-orientation of a magnetic oxide by means of a topotactical reaction. The initial mixture (*a*) contains a component consisting of crystallites of an oxide possessing strong magnetic anisotropy (hatched). This component is oriented by a magnetic field *H* and thus obtains a texture. The orientation of the other components (black) is not affected by the field. After firing (not in a field) a chemically different substance is produced (*b*, dense hatching) which exhibits the same texture as the oriented component in the initial material.

The topotactical reactions thus far investigated involve mainly compounds characterized in the composition diagram as shown in *fig. 4* by the points M, Me_2W, Me_2Y and Me_2Z, where M is an abbreviation for $BaFe_{12}O_{19}$ (ferroxdure), Me_2W for $BaMe_2Fe_{16}O_{27}$, Me_2Y for $Ba_2Me_2Fe_{12}O_{22}$ and Me_2Z for $Ba_3Me_2Fe_{24}O_{41}$. The reaction in our example is written in this notation as:

$$M\uparrow + 2CoO + 2Fe_2O_3 \rightarrow Co_2W\perp .$$

Compounds of the type Me_2Y and Me_2Z can be prepared in a similar manner.

Among the new possibilities opened up by topotaxy, the first to be mentioned is that a crystal-oriented material having a preferred *plane* of magnetization can now be made with the aid of a static magnetic field, which of course is easier to

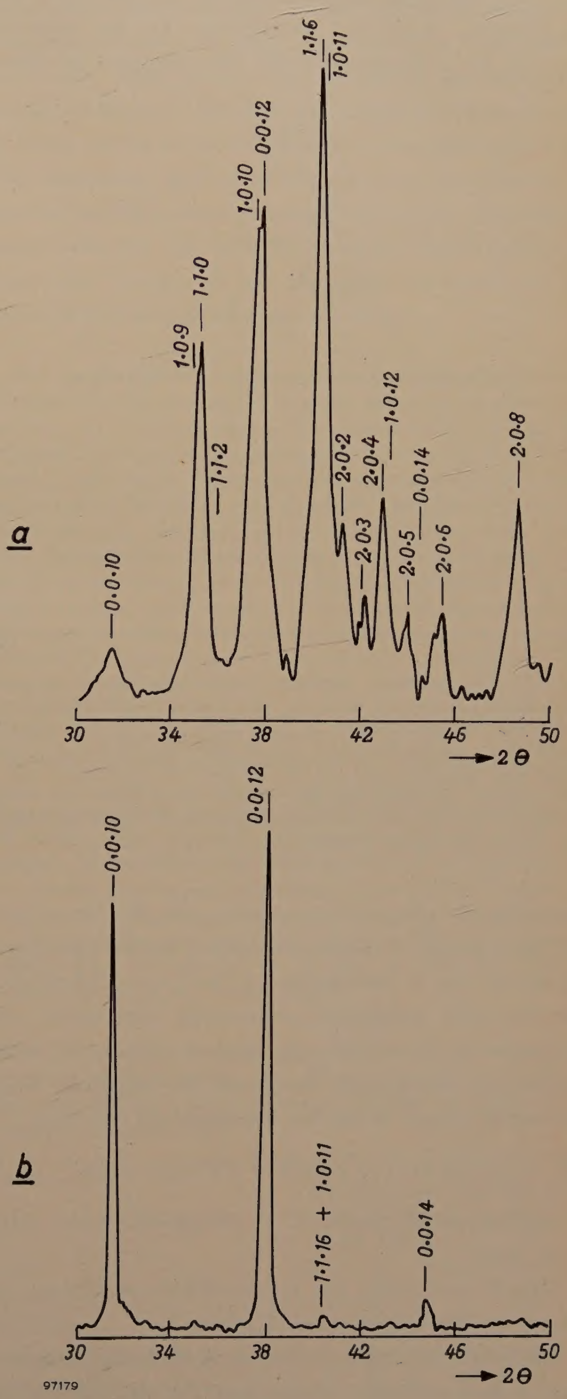

Fig. 3. *a*) X-ray diffraction diagram of non-oriented ZnCoW (abbreviation for $BaZnCoFe_{16}O_{27}$; see diagram in fig. 4). *b*) Diagram of oriented ZnCoW, prepared in accordance with the topotactical reaction $M\uparrow + ZnO + CoO + 2Fe_2O_3 \rightarrow ZnCoW\perp$. The only reflections occurring in this case are those originating from crystal planes perpendicular to the *c*-axis, showing that the material is indeed well-oriented.

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[6]) Research into the possibility of preparing materials in the manner described was prompted by the results of provisional experiments carried out by G. H. Jonker of this laboratory.

[7]) For further particulars regarding the choice of this name and its relation to "epitaxy" see: F. K. Lotgering, Topotactical reactions with ferrimagnetic oxides having hexagonal crystal structures, I, J. inorg. nucl. Chem. 9, 113-123, 1959 (No. 2).

set up than a rotating field. This is done by means of a topotactical reaction in which the orientable component in the starting mixture possesses a preferred *direction*. The reaction used above to explain the phenomenon of topotaxy is an example of this process.

Further, it is now possible to produce a well-oriented material which consists of crystals with insufficient magnetic anisotropy to be oriented directly by a magnetic field. One instance of this is found in the preparation of $Zn_{2-a}\,Co_aW$. For $a = 0$, we have Zn_2W, a substance with a distinct preferred *direction*. As a increases, i.e. as Co is substituted for Zn, the magnetic anisotropy decreases, and vanishes at $a \approx 0.65$. At higher values of a the anisotropy reappears, but now the material has a preferred *plane*. With the topotactical reaction

$$\mathbf{M}\!\uparrow + (2-a)\,\mathrm{ZnO} + a\,\mathrm{CoO} + 2\,\mathrm{Fe_2O_3} \rightarrow \mathrm{Zn}_{2-a}\,\mathrm{Co}_a\mathrm{W}$$

a well-oriented product is obtained, even when $a \approx 0.65$.

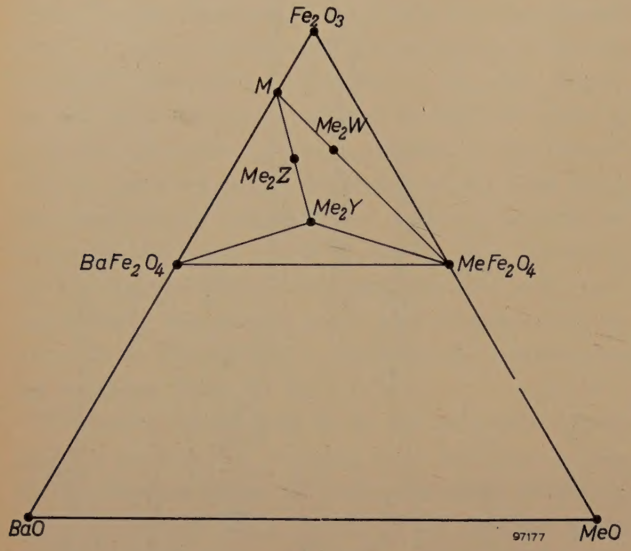

Fig. 4. Composition diagram indicating the compounds concerned in the topotactical reactions investigated here. They are the compounds **M** (i.e. $BaFe_{12}O_{19}$ = ferroxdure), Me_2W (i.e. $BaMe_2Fe_{16}O_{27}$), Me_2Y (i.e. $Ba_2Me_2Fe_{12}O_{22}$) and Me_2Z (i.e. $Ba_3Me_2Fe_{24}O_{41}$). The symbol Me represents one of the divalent elements Mn, Fe, Co, Ni, Zn or Mg or a mixture of these elements. For the compounds Me_2W, Me_2Y and Me_2Z, see the article quoted under [2]).

Other examples of topotactical reactions are given in the article quoted under [7]).

Materials having a preferred *direction* of magnetization and sufficient anisotropy for the old method can often be prepared more easily by the topotactical method. In preparing such a substance from the constituent oxides (mixed in the correct proportions) by means of a direct reaction, it is often found that after a single firing the required substance has formed only very incompletely. A repeated cycle of milling and firing is then necessary to achieve complete conversion. Frequently, however, a single firing can produce complete conversion if one of the basic substances used in the initial mixture is a substance such as **M** ($BaFe_{12}O_{19}$), which is itself a compound of two of the constituent oxides. In such a case it is possible by means of a topotactical reaction to produce in a single cycle not only a well-oriented but also a pure product. True, **M** must be available as a raw material, but this is a substance that can be produced directly in a single process from the oxides and is thus readily obtainable.

The topotactical method is at present being employed in the laboratory for preparing new materials for use in microwave directional isolators [8]). *Fig. 5* shows the hysteresis loops of such a material in the preferred direction and perpendicular thereto. These materials, which are required to have a slightly smaller anisotropy than ferroxdure, can be derived from ferroxdure by substituting Zn and Ti ions for a small fraction of the Fe ions in $BaFe_{12}O_{19}$ [9]). When these materials are prepared topotactically, they are found to be better formed and better oriented than when they are prepared from the oxides and subsequently directly oriented in a magnetic field.

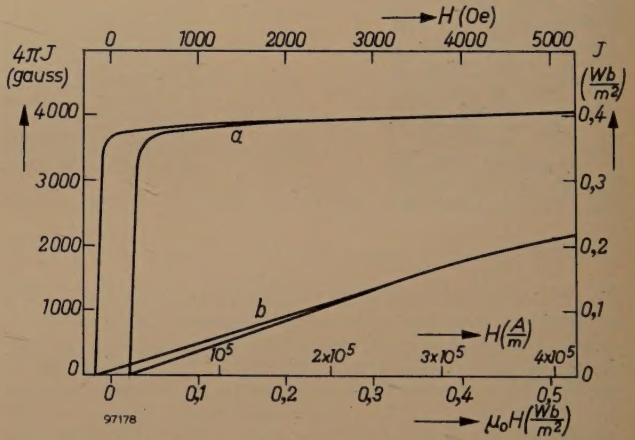

Fig. 5. Hysteresis loops of a topotactically crystal-oriented material intended for use in directional isolators, *a*) in a field *H* applied in the preferred direction, *b*) in a field perpendicular to the preferred direction.

F. K. LOTGERING.

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[8]) H. G. Beljers, Ferrite isolators in the 8-9 mm wave band, Commun. Congrès internat. Circuits et Antennes Hyperfréquences, Paris 21-26 Oct. 1957, part 2 (suppl. Onde électrique **38**, No. 376 ter), pp. 647-648, Aug. 1958.

[9]) E. W. Gorter, La variation de l'énergie magnéto-cristalline de $BaFe_{12}O_{19}$, produite par la substitution de Co^{2+} + Ti^{4+} à $2Fe^{3+}$, Colloque international de magnétisme, Grenoble 2-6 July 1958, published by "Centre national de la recherche scientifique", Paris 1959, pp. 303-304.

THE USE OF THERMISTORS IN THE EBULLIOSCOPIC DETERMINATION OF MOLECULAR WEIGHTS

621.317.39:536.531:541.24

Determinations of the molecular weight of chemical compounds are frequently carried out, especially in organic-chemistry laboratories. They serve primarily as a means of verifying, after completion of a synthesis, whether the compound intended has in fact been obtained. This method of verification is of particular importance in the preparation of substances that are seldom made or have never before been made, and whose physical constants are not precisely known. In the preparation of "known" substances it is more usual to measure for this purpose the melting point or the boiling point, or both, these being easier to determine than the molecular weight. In some cases both methods are combined.

The molecular weight M of a compound can be determined by making use of the phenomenon of boiling-point elevation. The boiling point of a solution differs from that of the pure solvent to an extent that depends on the concentration of solute "particles" in the solvent. If the solute is a non-dissociating substance, the "particles" are simply the molecules of the substance. If the substance does dissociate, each of the fragments acts as a "particle", and a higher boiling-point elevation is found. For *dilute* solutions the elevation Δt is proportional to the said number of particles, i.e. to the concentration of the solution. The proportionality factor, which is a characteristic of the *solvent* and which we call the molecular boiling-point elevation D, is expressed in °C per mole (gram-molecule) of solute [1] in 100 grams of solvent (sometimes also expressed per 1000 g solvent).

Since the fraction of a gram-molecule constituted by one gram of a substance is inversely proportional to its molecular weight, we can write:

$$\Delta t = D \frac{c}{M}, \quad \ldots\ldots \quad (1)$$

where c is now the concentration of the solution in grams per 100 grams of solvent. Values of D for some widely used solutions are given in *Table I.*

In practice, M is usually determined by performing a series of measurements on increasingly concentrated solutions of the investigated substance, and a similar series on a standard substance. The standard substance used is one whose chemical properties closely resemble those of the investigated substance; moreover it is one that can be prepared in a very pure state, and of course its molecular weight is known. The boiling-point elevations found in both series of measurements are plotted versus concentration, giving a straight line for each substance, which passes through the origin, in accordance with (1). M is then found by multiplying the molecular weight of the standard substance by the ratio of the slopes of the two lines.

The reason for using this apparently cumbersome method — after all, if D is known, M could be directly calculated from the slope — is that in practice the right-hand side of equation (1) must be multiplied by an extra factor f which often differs slightly from unity. This factor is a correction for systematic errors caused partly by the apparatus and the experimental conditions (e.g. the true concentration is higher than calculated owing to part of the solvent being in vapour form) and partly by the nature of the investigated substance (e.g. unsteady boiling, which can lead to errors in the measurement of Δt). Since the value of the factor f is not always known, it is advisable to determine M from a relative measurement, i.e. from a comparison with a standard substance for which f, by virtue of the chemical similarity of the substances, may be deemed to have the same value.

Moreover, graphical treatment of the measurements offers some advantages compared with calculating M from each measurement (with the aid of (1)) and subsequently averaging the results. The graphical method not only saves much calculation, but automatically takes account of the fact that the Δt-c curves pass through the origin. It also provides a means of checking on any anomalous behaviour of the substance, such as decomposition or association of molecules, or a chemical reaction with the solvent, for in such an event the relation between Δt and c is no longer linear.

Table I. The molecular boiling-point elevation D and the boiling point of some widely used solvents (arranged in order of ascending boiling point). Water is not one of these, but is included for comparison.

Solvent	D (°C per mole in 100 g solvent)	Boiling point °C
Acetone	17	56
Chloroform	36	61
Carbon tetrachloride	50	77
Ethyl acetate	28	77
Ethanol	12	78
Benzene	25	80
Cyclohexane	28	81
Iso-octane (2,2,4-trimethyl-pentane)	40	99
Water	5.2	100

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[1] A gram-molecule always contains the same number of molecules (6.025×10^{23}, Avogadro's number).

For a substance with a molecular weight of about 250 dissolved in a solvent of $D \approx 25$, at a concentration $c = 0.4$, the boiling-point elevation Δt is found from (1) to be about 0.04 °C. To determine a molecular weight with any precision we therefore need a thermometer capable of measuring extremely small differences of temperature. For the last half century the Beckmann thermometer has been used for this purpose. This is a variable-range mercury thermometer which, with its very large bulb and exceptionally fine bore, has a scale of about 5 cm per degree, graduated to hundredths of a degree. With a magnifying glass a reading can be taken to within 0.002 °C (0.1 mm on the scale). In the above example ($\Delta t \approx 0.04$ °C) it is therefore possible to determine M to within an error of 5%. The uncertainty in the result can be much greater in measurements on substances of high molecular weight, or when it is necessary to use a solvent of lower D (not all substances dissolve in liquids having a high D; in some cases a solution, although otherwise suitable, shows a quite considerable delay in boiling). The accuracy of the temperature measurement achieved with a Beckmann thermometer thus leaves something to be desired. Another drawback is the fairly high thermal inertia of the Beckmann thermometer. Since the boiling point of a liquid depends on atmospheric pressure, this means that measurements cannot be carried out at a time when the barometer reading shows marked fluctuations. At the very small differences of boiling point to be measured here, even slight variations in atmospheric pressure can be troublesome.

This situation made it desirable to look for a more sensitive temperature-measuring instrument of lower thermal inertia. It was found that a resistance thermometer equipped with a resistance element having a negative temperature coefficient (a thermistor) was capable of meeting the requirements. The absolute value of the temperature coefficient of these elements is extremely high, which gives the thermometer the necessary sensitivity. Further, the available resistance values offer a sufficiently wide range, and finally by using a bead-type thermistor the resistance element is extremely small and thus has a low heat capacity, which favours the rapid attainment of thermal equilibrium [2].

Very small differences in temperature, i.e. differences in the resistance of the thermistor, can be accurately measured by incorporating the thermistor in a Wheatstone bridge circuit. Starting from the balanced state of the bridge (no current through the galvanometer), a relatively small change in one of the resistances gives rise to a current, and hence a galvanometer reading, which for a small out-of-balance is proportional to the change in resistance. The galvanometer reading is thus proportional to the change in temperature [3].

A schematic representation of an apparatus for determining boiling-point elevations, a so-called ebullioscope, is shown in *fig. 1*. The liquid under test is contained in the boiler *A* and is heated by an element *B*. The reflux condenser *C* minimizes the escape of vapour. The vapour bubbles rising in the liquid above *B* enter *D* and cause the liquid, mixed with vapour bubbles, to ascend in three narrow tubes *E* [4]. The pumped-up liquid finally flows back along the outside wall of the tube *F*, the return path being lengthened by the glass spiral *G* in order to promote good heat transfer to *F*. The sensitive element of the thermometer — the thermistor instead of the mercury reservoir of a Beckmann thermometer — is contained in the tube *F*, being immersed (to improve thermal contact) in a little silicone oil. The space between the boiler and the jacket *H* contains the vapour of the pure, boiling solvent. This space acts as a heat insulator. The vapour is produced by boiling in the vessel *J* a certain quantity of the same solvent as contained in *A*. The vapour is condensed in a condenser *K* and the condensate finally returns to *J* via a trap *L*. After the measurement the used liquids can be drained through the capillary *M* and the container *N* and by removing the stopper *O*.

The bridge circuit contains a second thermistor identical with the measuring thermistor (approx. 52 kΩ at 25 °C), two fixed resistors of 5100 Ω each, and two variable resistors, one of 1000 Ω and the other of 10 Ω, for balancing the bridge. The inclusion of a second, identical thermistor gives the following advantages. Since thermistors are extremely temperature-sensitive, it would be necessary,

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[2] The required sensitivity can also be obtained with a platinum resistance thermometer. However, a long length of platinum wire is then called for — the temperature coefficient of the resistance of Pt is small — which makes the thermal inertia of the instrument much higher than with a thermistor.

[3] This proportionality applies only within a very narrow temperature range. If the temperature varies over a wider range, the resistance of a thermistor no longer changes linearly with temperature. Consequently the sensitivity of the resistance thermometer (galvanometer deflection per °C) depends on the temperature at which the measurement is made. Since we always determine M by comparison with a standard substance dissolved in the *same* solvent, this is no drawback whatsoever for the present purposes.

[4] The principle and operation of a "vapour-bubble pump" were discussed in a recent article in this Review (see Philips tech. Rev. **20**, 177, 1958/59, No. 7).

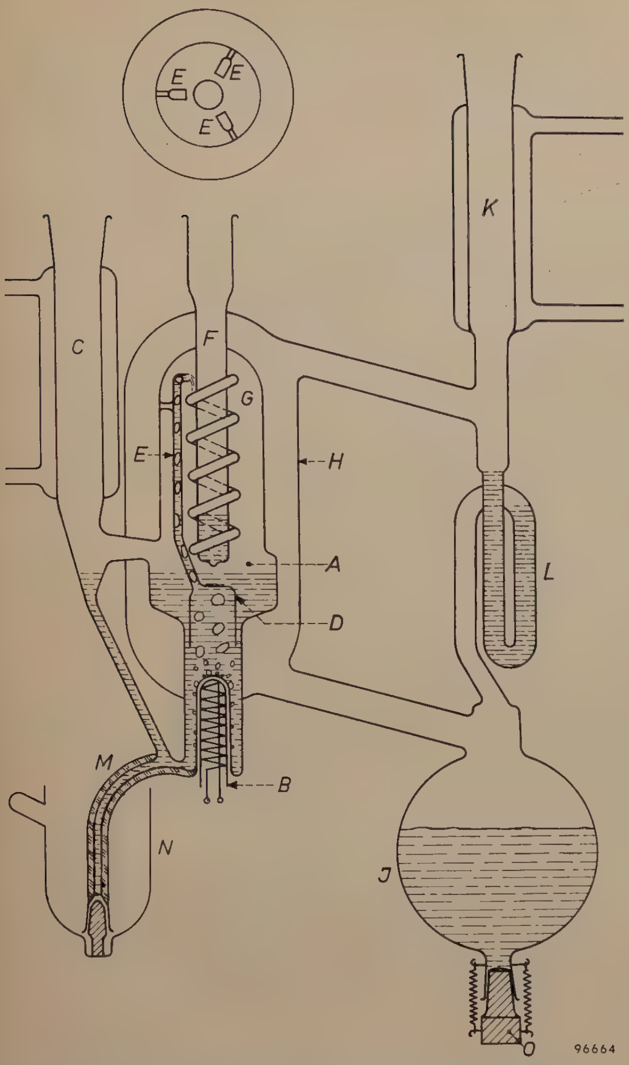


Fig. 1. Schematic representation of an ebullioscope with a vapour jacket as designed by the Central Institute for Physico-Chemical Constants (C.I.P.C.), Utrecht.

if only one were used, to alter the adjustment of the bridge considerably when changing over after a measurement with a solvent boiling at, say, 80 °C to a solvent boiling at 100 °C. By incorporating a second and identical thermistor in the circuit, and by keeping it at the boiling temperature of the pure solvent for each measurement, the circuit is always approximately balanced no matter what solvent is used. It is because of this that the potentiometers for balancing the bridge can have the small values mentioned. In the second place it is possible in this way to keep the set-up very stable in relation to variations in extraneous conditions (atmospheric pressure, room temperature, etc.). The best method of achieving this is to place the second thermistor in a separate but identical ebullioscope, the boiler of which contains the pure solvent.

Fig. 2 shows a diagram of the bridge circuit together with its power supply circuit. The set-up of the two ebullioscopes can be seen in *fig. 3*.

The application here discussed imposes very high demands on the constancy of the thermistors. The bead-thermistor thermometers mentioned (Philips B8.320.05P) have proved to be entirely satisfactory in this respect: the variation in the value of resistance was found to be smaller than 1 in 10^5, whilst the sensitivity of the circuit (galvanometer deflection per °C) seldom differed by more than $\frac{1}{2}$% from the mean value.

Before use the thermistors are artificially aged by keeping them for one day at a temperature of 150 °C; this is 50 °C higher than the highest working temperature.

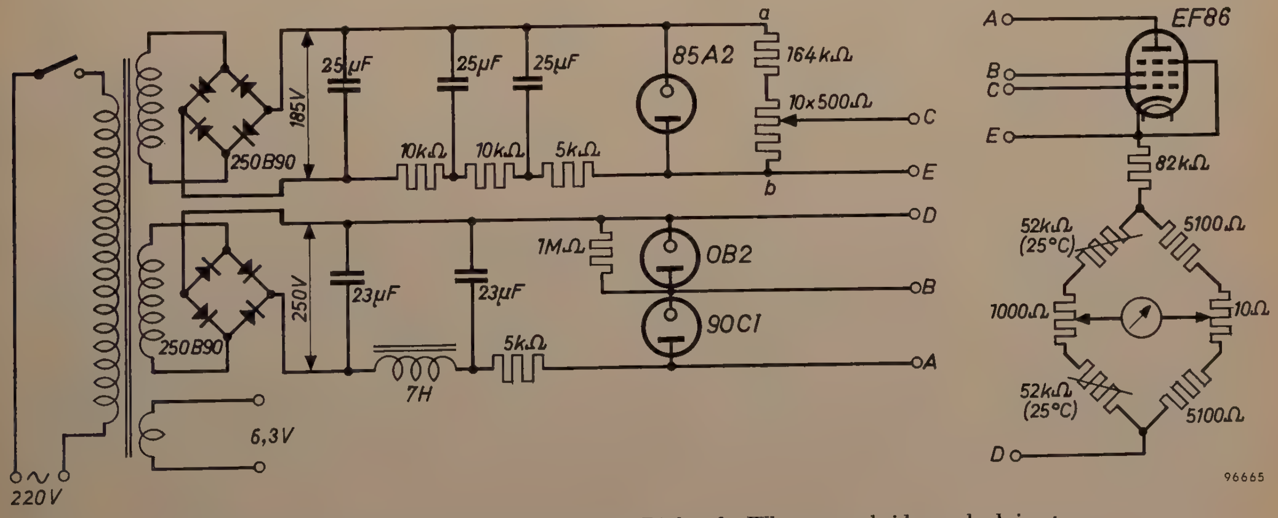


Fig. 2. Circuit of the resistance thermometer. Right, the Wheatstone bridge embodying two thermistors. Left, the power supply circuit providing the required stabilized direct voltages. The two sections are connected at the points marked *A* to *E*. A high degree of stability is provided by feeding the bridge circuit with the anode current of a pentode. This current can be varied by changing the control-grid voltage (*C*-*E*), which is tapped from the voltage divider *a*-*b* via a 9-position switch.

The thermistors are not used in the form in which they are sold; the glass tube is first shortened from 12 to 2 cm (*figs. 4* and *5*). This is done in order to make it possible to keep the soldered joints between the lead-in wires and the silver wires that form the connections to the rest of the circuit at an equal and constant temperature; this is necessary to prevent the occurrence of a thermo-e.m.f. With the shortened thermistor tube the soldered joints can also be immersed in the silicone oil.

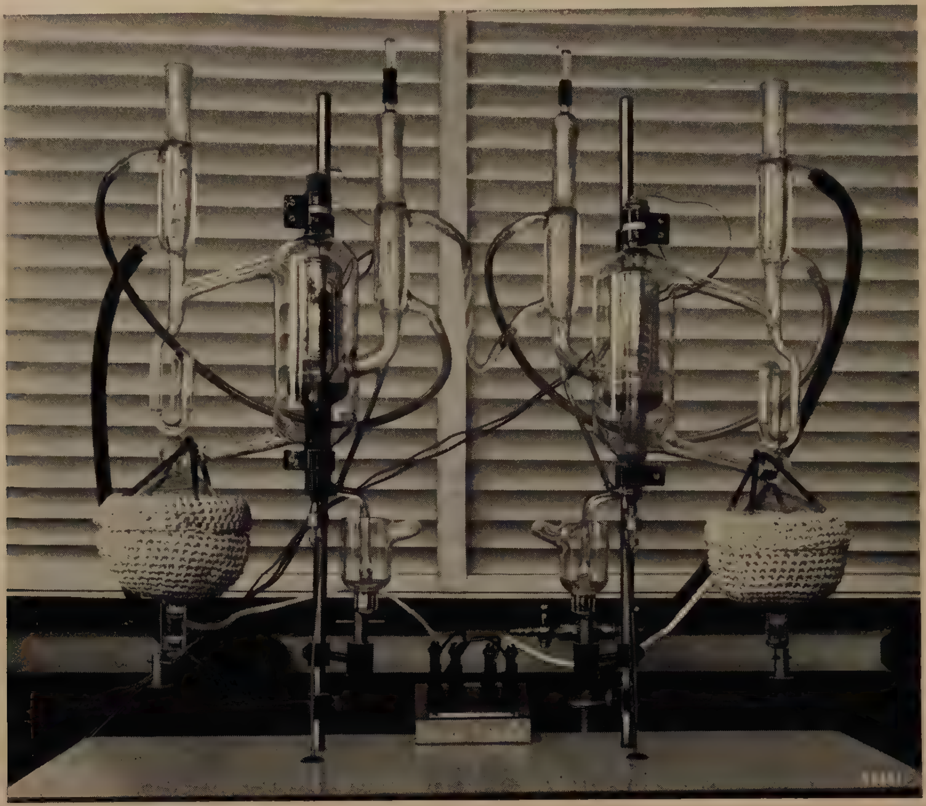


Fig. 3. Ebullioscopic apparatus embodying thermistor thermometers for the measurement of temperature differences.

With the apparatus described it is possible to measure temperature differences with an accuracy of about 3×10^{-4} °C. This means that a molecular weight of, say, 2500 can now be determined with an accuracy of a few per cent, and molecular weights smaller than 500 with an accuracy better than 1%. Moreover, for investigations on substances of low molecular weight it is now possible to use solvents having a low molecular boiling-point elevation, and thus to perform measurements on all kinds of sub-

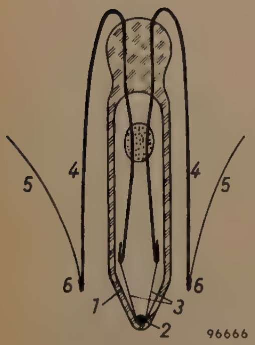


Fig. 4

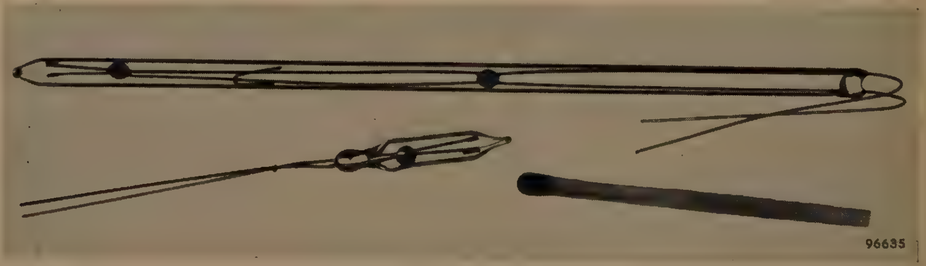
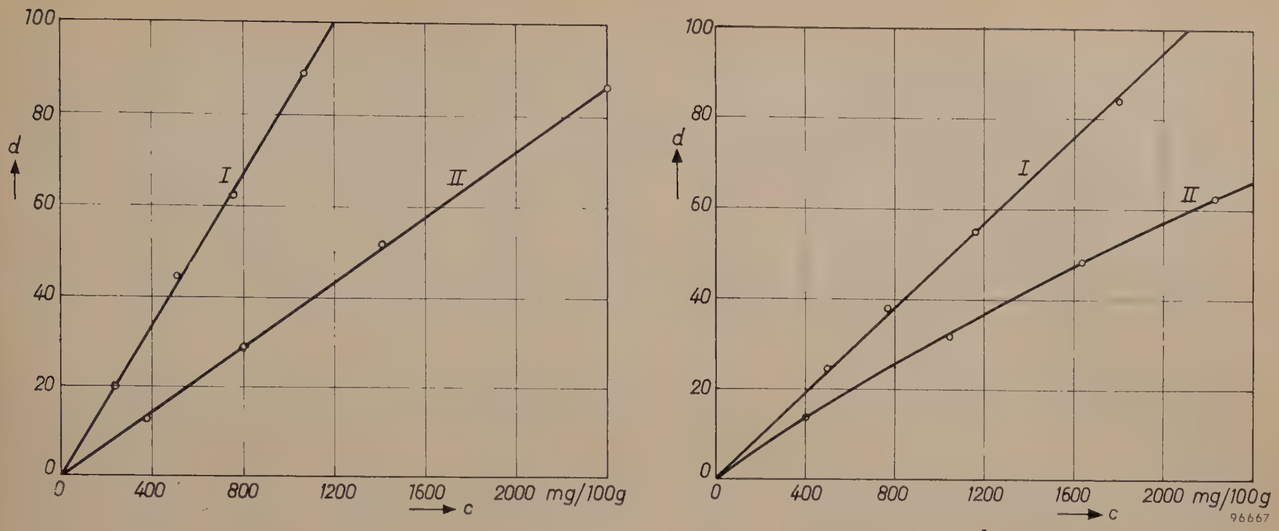


Fig. 5

Fig. 4. Schematic cross-section of the bead thermistor employed (twice actual size). *1* glass tube, *2* thermistor bead, *3* platinum wire connections to bead, *4* lead-in wires, *5* silver wires, *6* soldered joints.

Fig. 5. Thermistor suitable for ebullioscopic molecular-weight determination (below), with a Philips thermistor type B8.320.05P, from which it is made by shortening the glass tube.



a *b*

Fig. 6. *a*) The galvanometer deflection *d* (in arbitrary units) as a function of the concentration *c* of solutions of α-naphthol (standard substance, $M = 144$, curve *I*) and 2-diphenylacetyl-1-naphthol ($M = 338$; curve *II*) in benzene. Both curves are straight lines through the origin, and their slopes are inversely proportional to the molecular weights. *b*) The same for β-ionone (standard substance, $M = 192$) and β-cyclocitrylidene acetic acid ($M = 194$). The curve for the latter substance is not a straight line. A reaction apparently occurs which makes it impossible to determine the molecular weight of this substance with the aid of a solution in benzene.

stances that do not dissolve in the liquids hitherto employed.

Fig. 6 shows the results of some molecular-weight determinations by the method described above. Fig. 6*a* gives an example of linear relations between the galvanometer deflection and the concentration of the solution for the tested and for the standard substance. Fig. 6*b* represents measurements in which the linear relationship was found for the standard substance but not for the other.

J. G. van PELT *).

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*) N.V. Philips-Duphar, Weesp (Netherlands).

TRANSISTOR D.C. CONVERTERS FOR FLUORESCENT-LAMP POWER SUPPLIES

by T. HEHENKAMP and J. J. WILTING.

621.314.5:621.314.7:
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It has been known for some years that transistors can be used to convert direct current into alternating current with a surprisingly high efficiency. This opens up new possibilities with regard to the running of fluorescent lamps from low-voltage D.C. supplies.

Accumulators are the only source of supply available for the lighting of certain kinds of vehicles, including omnibuses and other road transport, many types of trains, and river and canal craft. The power available from accumulators is always on the low side, because the number and size of accumulators carried is determined by considerations of weight and expense. For the lighting of such vehicles it is therefore a prime condition that the installation should work with high efficiency. Now, high efficiency is one of the characteristic properties of low-pressure fluorescent lamps. It is not therefore surprising that increasing use is being made of these lamps in vehicles [1]).

Running fluorescent lamps direct from an accumulator has two disadvantages. One is of a general nature, arising whenever gas-discharge lamps are supplied from batteries. The difference between the supply voltage and the lamp voltage has to be dropped across a ballast resistor involving power losses much higher than those occasioned by the impedance that is used in an A.C. circuit. The lamp voltage is about 0.5 to 0.6 of the supply voltage. Consequently the circuit efficiency (i.e. the ratio between the power consumed by the discharge and the power taken from the battery) is no more than 50 or 60 per cent.

The second disadvantage is that fluorescent lamps are not particularly suitable for running from the 6, 12 or 24 V batteries commonly fitted in vehicles. Ignition of the short "TL" C lamps, for example, which have lengths of 38 cm and 47 cm and which were developed for train lighting [1]), calls for a battery with a rated voltage of 72 V, which is not normally available. For longer lamps, which have the advantage of higher efficiency, an even higher voltage is required.

In the many cases where the available battery voltage is too low for the fluorescent lamps it is desired to instal, some form of converter has to be used. Indeed, a converter is sometimes employed when the battery voltage *is* high enough, with a view to improving efficiency; such a device can be made to supply alternating current, and so permits ballast losses to be cut down. The alternating voltage from the converter can moreover be stepped up to 220 V, and this enables one to make use of the longer "TL" lamps, which have a higher efficiency than short ones.

Of all the various kinds of converter that will serve the purpose, the centrifugal type (mercury jet interrupter [2])) is the most commonly used. It allows the circuit efficiency to be raised to about 70%.

An important feature of devices converting D.C. into A.C. is that they allow a choice of frequency. There are various reasons for making the lamp supply frequency higher than the normal mains frequency of 50 c/s. Firstly, the efficiency of a fluorescent lamp increases with frequency — see *fig. 1.* Secondly, the higher the frequency, the smaller the ballasts can be and the lower are the losses incurred. Thirdly, increasing the frequency reduces the ripple in the luminous flux, making the light

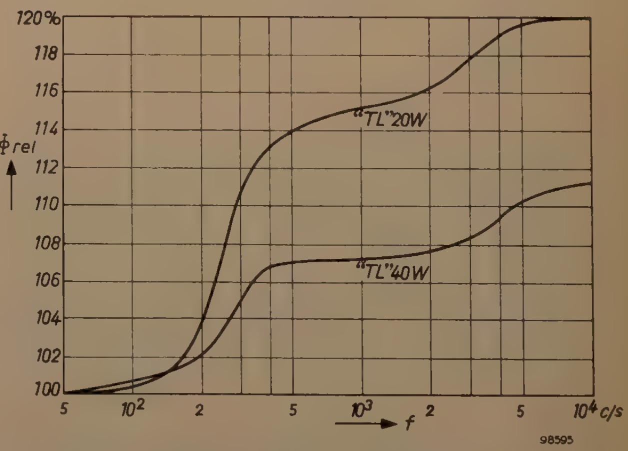

Fig. 1. Relative luminous flux $\Phi_{\rm rel}$ from a 20 W and a 40 W "TL" lamp, as a function of the frequency f of the supply current, the power consumed by the discharge being constant. $\Phi_{\rm rel}$ is taken to be 100% at f = 50 c/s.

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[1]) L. P. M. ten Dam and D. Kolkman, Lighting in trains and other transport vehicles with fluorescent lamps, Philips tech. Rev. 18, 11-18, 1956/57.

[2]) See page 13 et seq. in the article cited in footnote [1]).

more restful. This is of importance in vehicles, where lighting has to satisfy more stringent requirements in this respect, owing to jolting and vibration (stroboscopic effects).

For these reasons D.C. converters are always operated at frequencies higher than 50 c/s; centrifugal converters are usually run at 100 c/s, and rotary converters of the conventional type work at 100 c/s or 150 c/s and sometimes at frequencies up to 1000 c/s. We shall presently discuss a type of converter which can be operated at still higher frequencies.

Excellent lighting installations can be based on the principles just described, and this has in fact been widely done. Nevertheless, these installations still leave something to be desired. It would be a good thing if the rotary converters could be replaced with static devices requiring very little maintenance. Higher operating frequencies are also desirable, the main reason being that they would allow ballast size to be reduced. And, of course, a further increase in efficiency would be welcome.

New opportunities of fulfilling these desiderata have arisen in consequence of the development of the transistor and in particular of high-power types. These devices enable direct current to be converted conveniently and efficiently into alternating current at frequencies up to many kilocycles/sec [3]).

Fig. 2a shows one of the simplest arrangements for converting D.C. into A.C. with the aid of transistors, the resistance R_0 representing the load. The two transistors function as switches, not as amplifying devices. Each in turn admits current (which flows from emitter to collector, in the transistor) and the transformer delivers a voltage that is practically square in shape. The transistors can switch relatively high powers and this is due, firstly, to the fact that the voltage drop across a conducting transistor is very small and, secondly, to the fact that the leakage through a cut-off transistor is negligible, even for a high reverse voltage. Only *during* the actual switching process does a fairly heavy current through the transistors coincide with an appreciable potential difference across them, but the switching intervals only represent a small fraction of the period.

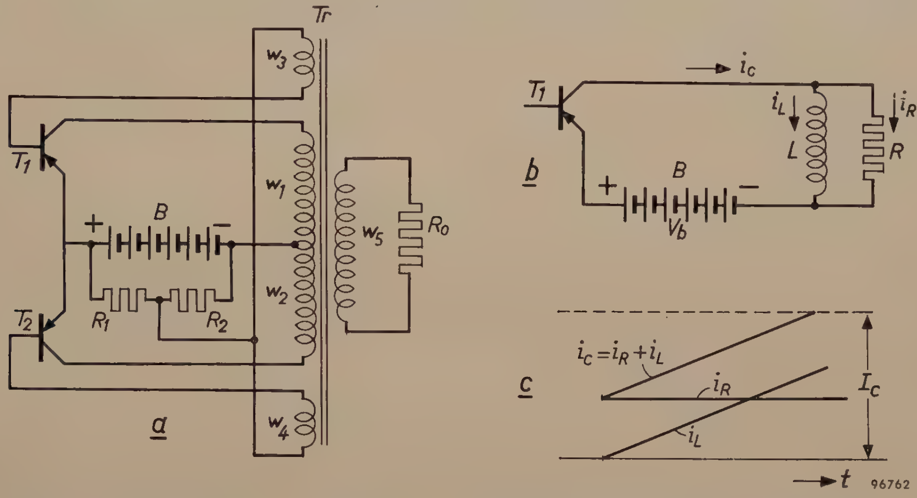

Fig. 2. *a*) Simplified circuit of a transistor D.C. converter, with load resistance R_0. *B*: supply battery. T_1, T_2: *P-N-P* type transistors. *Tr*: transformer with primary windings w_1-w_2, feedback windings w_3-w_4 and secondary winding w_5. Voltage divider R_1-R_2 gives the bases a small negative bias with respect to the emitters.
b) Windings w_1 and w_5 and the load resistance R_0 replaced by a parallel arrangement of an inductance L (the no-load inductance of w_1) and a resistance R (the resistance R_0 transferred to the primary side).
c) The collector current i_C in (*b*) may be divided into two components, a constant current $i_R = V_b/R$ and an increasing current $i_L = V_b t/L$. The current i_C stops increasing when $i_C = i_R + i_L$ has attained the value I_C.

The frequency at which the circuit operates is determined by the load, the supply voltage, the transistor characteristics and the no-load inductance of the primary windings (w_1 and w_2 in fig. 2*a*) of the transformer. It has been found quite practicable to generate frequencies of several kilocycles/sec.

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[3]) See for example: G. H. Royer, A switching transistor D.C. to A.C. converter having an output frequency proportional to the D.C. input voltage, Trans. Amer. Inst. Electr. Engrs. **74 I** (Communication and Electronics), 322-324, 1955, and the chapter by L. H. Light entitled "Transistor D. C. converters" in "The junction transistor and its applications", edited by E. Wolfendale and published by Heywood & Co., London 1958.

A short explanation of the operation of the circuit in fig. 2*a* may be given here.

Consider the situation following an instant at which T_1 has switched into the conducting state and T_2 into the cut-off state. Current from the battery passes via the emitter and collector of T_1 and energizes w_1. The potential difference across w_1 (and w_2) is then not much less than the full battery voltage V_b, and w_3, w_4 and w_5 likewise have constant voltages across them. The windings w_3 and w_4 are so chosen that the former gives the base of T_1 a higher negative potential than that conferred on it by the voltage divider R_1-R_2, whereas w_4 gives the base of T_2 a positive potential. This is in accordance with the conducting state of T_1 and the cut-off state of T_2.

We now imagine windings w_1 and w_5 and resistance R_0 to be replaced by an inductance L (the no-load inductance of w_1) in parallel with a resistance R (being the resistance R_0 transferred to the primary side) — see fig. 2*b*. The voltage across this parallel arrangement is V_b (the drop in T_1 being disregarded). Accordingly, the collector current i_C can be split up into two components, a constant current $i_R = V_b/R$, and a current $i_L = V_b t/L$ which (provided L is constant) grows linearly with time (t). Hence the total collector current is increasing, but it cannot continue to do so indefinitely because it is subject to an upper limit I_C determined by the (constant) voltage between emitter and base. Once i_C has attained the value I_C, it cannot increase any further; nor can its component i_L. Thus di_L/dt becomes zero, which means that all the transformer voltages collapse. The disappearance of the feedback voltage across w_3 causes the base current of T_1 to diminish, i_C falls off too and the result is that the transformer windings now have voltages of the opposite sign induced in them. This cuts off T_1 and causes T_2 to become conducting, and the situation in T_2 and w_2 is the same as that which previously obtained in T_1 and w_1.

In this way the circuit alternates periodically between two states. The transformer output voltage is practically square in shape. If the brief switching interval be disregarded, one half-period is equal to the time required by i_C to grow from the value V_b/R to the value of I_C appropriate to the voltage present on the base (fig. 2*c*). This time will obviously be all the shorter, and the frequency of oscillation all the higher, according as L, R and I_C are smaller and V_b higher.

The load resistance in fig. 2*a* cannot simply be replaced by a fluorescent lamp without further ado, the main reason being the difference between the striking and operating voltages of the lamp. It might seem on the face of it that this difficulty could be avoided merely by having the unloaded transformer deliver a voltage higher than the striking voltage. However, once the lamp has ignited, the transformer has to deliver the much lower operating voltage. As far as the transformer output voltage is concerned, then, the transistors are either overloaded before the lamp strikes or underloaded afterwards. This being so, it will be advisable to take steps to bring the lamp striking and operating voltages as close to each other as possible. The following are well-known measures that can be taken to this end.

1) Heating the electrodes by means of a separate heating current. These currents can be obtained from extra transformer windings (w_6 and w_7 in *fig. 3*).
2) Fitting a conductive strip to the outside of the lamp. A higher voltage is applied to the strip than is available for the lamp itself, and for this purpose the secondary winding of the transformer is extended (w_8, fig. 3).

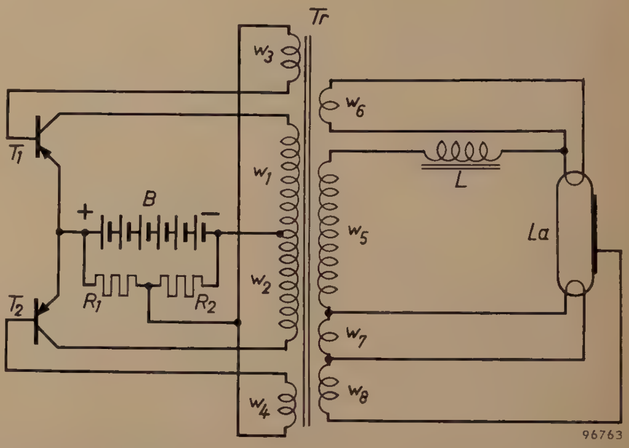

Fig. 3. Simplified circuit of a transistor converter supplying a fluorescent lamp *La*. Transformer *Tr* is somewhat more elaborate than that in fig. 2*a*, having heater windings w_6 and w_7 and a winding w_8 whose purpose is to supply a high potential to the conductive strip on the outside of the lamp. *L* is a choke in series with the lamp. The other letters have the same meaning as in fig. 2*a*.

In the second place, when the load resistance is replaced by a fluorescent lamp, account has to be taken of the downward sloping current/voltage characteristic of the latter. Once the lamp ignites the instantaneous value of collector current through the transistors rapidly increases, with the result that the converter starts to oscillate at a much higher frequency and becomes unstable. The remedy is to insert a choke (L in fig. 3) in series with the lamp.

The simple circuit shown in fig. 3 allows efficiencies of round about 50% to 55% to be achieved. Everywhere circuits are being developed with a view to getting higher efficiencies. Endeavours are being made to shape the current passing through the transistors during the switching intervals in such a way as to reduce losses in the transistors. *Fig. 4* shows one of the transistor converters developed at Philips. It has an efficiency of over 60%. The high frequency (several kilocycles/sec) at which it operates and the use of ferroxcube have made it possible to keep down the size of the transformer and the choke. The high frequency has the further advantage of raising the lamp efficiency to a figure considerably higher than that obtained at 50 c/s — see fig. 1.

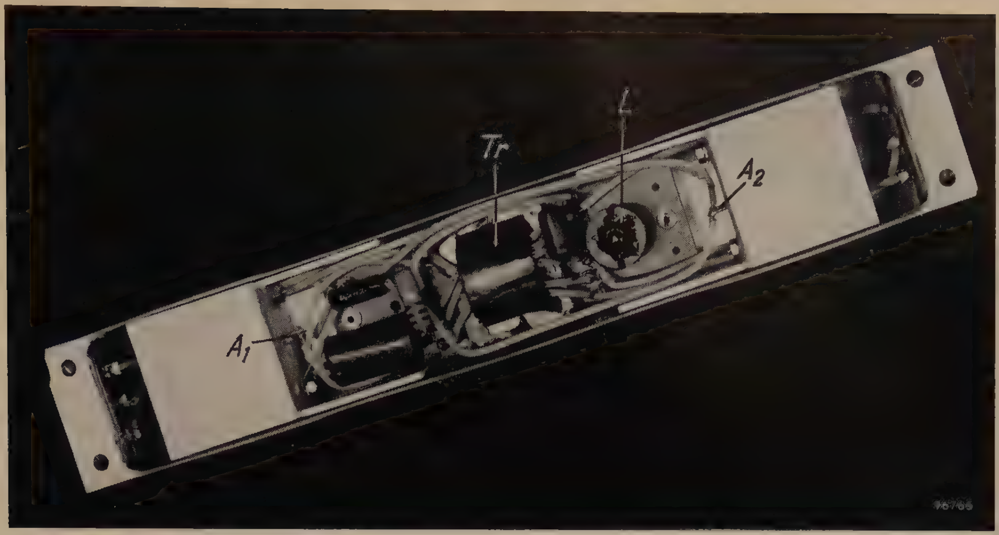

Fig. 4. One of the experimental D.C. converters. All that can be seen of the transistors is their connecting tags (A_1-A_2). Transformer *Tr* and choke *L* have ferroxcube cores.

The term "circuit efficiency" as used in this article requires some explanation.

The power input into the converter is the product of the battery voltage and the mean battery current, and is therefore easy to determine. Part of the output goes to heat the electrodes (and is therefore only indirectly useful) and the remainder is consumed by the discharge. It is clearly desirable to know what proportion of the converter output goes to the discharge, but its measurement is not easy.

A similar difficulty arises in connection with (mains) lamps in starterless circuits. A circuit used with the "TL" M lamp [4]) is given by way of example in *fig. 5*. Not one branch of the circuit carries the same current as that of the discharge, and the straightforward measurement with a wattmeter of the power supplied to the discharge is not therefore possible.

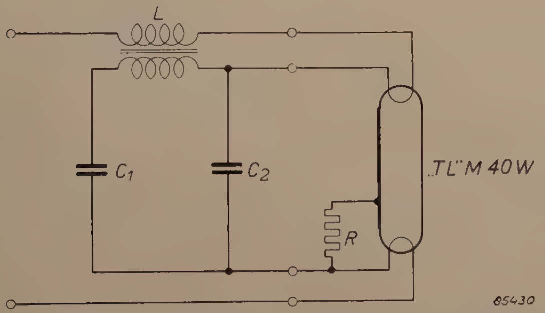

Fig. 5. Starterless circuit of "TL" M lamp — an example of a circuit in which it is difficult to measure the power actually dissipated in the discharge. (For an explanation of the circuit, reference may be made to fig. 4 in the article cited in footnote [4]).)

The following method has gained fairly wide acceptance internationally as a way of getting round the difficulty. The lamp is run from the circuit under investigation (*fig. 6a*) and a photocell connected to a millivoltmeter is set up in its vicinity. Without altering the set-up in any way, the lamp is switched over to the simple circuit shown in fig. 6*b*. The same lamp is now in series with a choke and is being supplied from a variable transformer connected to the mains (but no heating currents are now being supplied, however). The transformer is adjusted to give a current through the lamp such that the millivoltmeter deflection is the same as before. The value indicated by the wattmeter included in the second circuit is considered to be equal to the power *P* consumed by the discharge in the circuit of fig. 6*a*.

Practical considerations persuaded us to make use of this method in our development work on transistor converters for fluorescent lamps. For simplicity we have not incorporated any correction in respect of the difference in lamp efficiency; this is higher when the lamp is run from the converter than when it is supplied from the mains (the correction is dependent on the type of lamp). Hence the efficiency figures already quoted, and those that will be given below, are too high by reason of the fact that this correction has not been made, but they are too low for another reason, namely that the electrode losses are not included in *P*.

Two of the converter types that we have developed are undergoing practical trials in vehicle lighting installations. One of the installations is in a 'bus of a service operating in the vicinity of Eind-

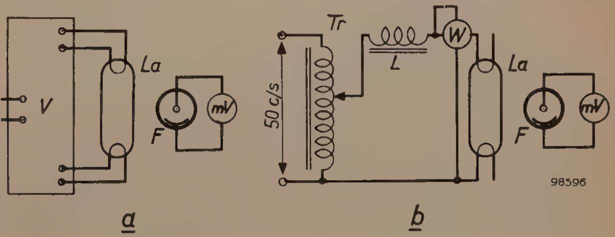

Fig. 6. *a*) *La* is a fluorescent lamp and *V* the ballast (or converter) in a circuit of a kind where direct measurement of *P*, the power dissipated in the discharge, is impracticable. *b*) Here the same lamp *La* is in series with a choke *L*, no heater currents being supplied. The wattmeter in the circuit allows *P* to be determined. It is assumed that the value indicated is valid for circuit (*a*) provided the millivoltmeter connected to photocell *F* gives the same deflection in both cases. The variable transformer *Tr* is adjusted until the photocell voltage in circuit (*b*) is equal to that obtained in circuit (*a*).

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[4]) Philips tech. Rev. **17**, 291 et seq., 1955/56.

hoven. Five 20 W "TL" lamps of the type with a conductive strip have been installed in the 'bus, each fitting accommodating one lamp and the associated transistor converter. The battery voltage is 12 V, the converter oscillates at a frequency of about 4 kc/s and its efficiency is about 65%. The installation has been in service for over a year, giving full satisfaction.

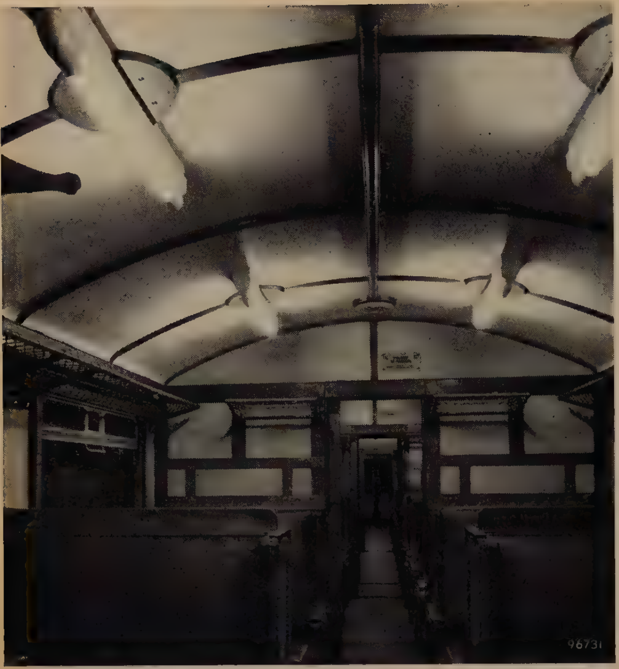

Fig. 7. Experimental installation in a carriage of the Netherlands Railways. It consists of 20 fluorescent lamps each of 20 W. Each of the lamp fittings contains a transistor converter. The supply voltage is 24 V, the frequency approx. 7 kc/s and the efficiency approx. 62%.

The second installation is in a railway carriage of the Netherlands Railways (*fig.* 7). Twenty 20 W "TL" lamps, likewise with conductive strips, are mounted in fittings having contact caps of the standard type used in Dutch railway carriages. Each fitting has its transistor converter. In this case the battery voltage is 24 V, the converter works at about 7 kc/s and has an efficiency of about 62%. The installation has been in service for about six months, also without any trouble.

Experience gained from laboratory tests and from these installations shows that the transistor converter represents an excellent solution to the problem of running fluorescent lamps from low-voltage batteries. The life of the lamps has been found to exceed 7000 hours, during which time the characteristics of the transistors do not undergo any perceptible change. The efficiency of the circuit surpasses that of many rotary converters but is somewhat less than that obtainable (70%) from mercury jet converters. However, it is likely that the static converters will soon be freed from this slight drawback. An efficiency of over 80% has been attained with new circuits that are still undergoing development.

Summary. Description of experimental transistor converters which convert D. C. into A. C. with output powers up to about 20 W. The particular application concerned here is to furnish an A.C. supply for fluorescent lamps in circumstances where efficient lighting is desired but where the only source of electricity available is a low-voltage accumulator of limited capacity. The converters operate at frequencies of several kilocycles/sec; the advantages of the high frequency are that the lamp efficiency is raised to a figure about 20% higher than that obtained at 50 c/s, the ripple in the light given becomes so slight as to be imperceptible, and the bulk of the converter and ballast can be kept down. Trial installations in a train and a 'bus, working with efficiencies between 62% and 65%, have given satisfactory results. An efficiency of over 80% has been obtained from more recent circuits.

ABSTRACTS OF RECENT SCIENTIFIC PUBLICATIONS BY THE STAFF OF N.V. PHILIPS' GLOEILAMPENFABRIEKEN

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2620: R. Vermeulen: Stereo-reverberation (J. Audio Engng. Soc. **6**, 124-130, 1958, No. 2).

The quality of reproduced music depends not only on the true reproduction of the complete spectrum and the absence of spurious sounds (noise and distortion products), but also on the distribution of the sound over the listening room. Stereophonic reproduction can simulate the directions of the direct sound and thus can imitate, for instance, an orchestra in a satisfactory manner. This is not sufficient, as the room acoustics of the concert hall are essential. The diffuse character of the reverberated sound cannot be reproduced by a single loudspeaker or group of loudspeakers, and only in a limited way by stereophony. It can, however, be reconstructed, even from a single channel, by "ambiophony", i.e. by feeding several loudspeakers distributed over the hall, with different and aleatory delays, repeated many times at decreasing levels. See also Philips tech. Rev. **17**, 258-266, 1955/56; **20**, 309-326, 1958/59 (No. 11), and **21**, No. 2, to appear shortly.

2621: A. A. Kruithof: Die Lichtausbeute von Niederdruck-Leuchtstofflampen (Elektrizitätsverwertung **33**, 23-28, 1958, No. 2). (The luminous efficiency of low-pressure fluorescent lamps; in German.)

Although in an industrial community the absolute value of the energy consumed for lighting is relatively small compared with the energy converted into heat and mechanical energy, it is nevertheless important to increase the efficacy both of existing light sources and (especially) of new light sources. The author considers the mechanism of light production in low-pressure fluorescent lamps and distinguishes between two somewhat opposed criteria as regards the efficacy: these are the attainment of the highest possible luminous efficiency and the attainment of the best colour rendering properties (nearest approximation to daylight or incandescent light, etc.). See also Philips tech. Rev. **18**, 249-260, 1956/57.

2622: A. L. Zijlstra and A. M. Kruithof: L'élasticité différée d'un verre borosilicate et son influence sur la formation de contraintes dans des scellements de ce verre (Verres et Réfractaires **12**, 127-141, 1958, No. 3). (Delayed elasticity in a borosilicate glass and its effect on the formation of stresses in seals of that glass; in French.)

After an introduction to delayed elastic effects such as observed in glass, particularly in the transformation range, the writers describe in detail the delayed elasticity occurring in a borosilicate glass. The maximum deformation due to delayed elasticity can be 70 times that of instantaneous elasticity. The possibility of "freezing-in" an amount of the delayed elastic deformation is examined. This frozen-in delayed elasticity plays an important role in the formation of stresses in glass seals and it gives rise to smaller or larger deviations from the results obtained by the formulae that Hull and Burger have established in respect of stresses in glass-to-metal bead seals. For some bead seals of borosilicate glass, the effect of delayed elasticity on the formation of stresses has been stated. A method is discussed which makes it nevertheless possible to calculate these stresses by giving the formulae of Hull and Burger a more general form; this method takes into account the effect of delayed elasticity.

2623: J. Rodrigues de Miranda: Push-pull amplifiers drive speaker directly (Electronics **31**, No. 29, 76-79, 18 July 1958).

A single-ended push-pull output of a 10-watt amplifier directly feeds the voice coil of a loudspeaker making an output transformer unnecessary. The first pre-amplifying stage has positive feedback to the point of oscillation, while the first amplifier and output stages have negative feedback. The resulting circuit is stable, has low distortion, flat response and only a few degrees phase shift over the audio range. See also Philips tech. Rev. **19**, 41-49, 1957/58 (No. 2).

2624: K. Compaan and Y. Haven: Correlation factors for diffusion in solids, II. Indirect interstitial mechanism (Trans. Faraday Soc. **54**, 1498-1508, 1958, No. 10).

The relation between diffusivity D and conductivity σ of ions (N per cm^3, charge e) in ionic crystals is given by a relation of the type $D = f\sigma kT/Ne^2$, where f accounts for the correlation between the directions of successive steps of an atom. In this paper the value of f is calculated for the indirect interstitial mechanism of transport in a few types of ionic crystals. The method of calculation is described.

2625: Y. Haven and J. H. van Santen: Dielectric relaxation of lattice defects in crystals (Suppl. to Nuovo Cimento **7** (series X), 605-611, 1958, No. 2).

Relaxation phenomena due to lattice defects in crystals can be discussed with group-theoretical methods, if so-called relaxational modes are introduced. As an example the dielectric relaxation of NaCl containing small amounts of $CaCl_2$ is discussed and compared with mechanical relaxation. See also Philips tech. Rev. **20**, 69-79, 1958/59 (No. 2/3).

2626: H. G. van Bueren, J. Hornstra and P. Penning: Dislocations in germanium and silicon (Suppl. to Nuovo Cimento **7** (series X), 646-660, 1958, No. 2).

This paper describes some recent work in Eindhoven on the subject of dislocations in the diamond structure and on the plastic deformation of its most important representative — germanium. Three topics are discussed: the nature of dislocations in germanium and silicon, the formation of dislocations by thermal stresses, and certain general aspects of the plastic deformation of germanium. See also Philips tech. Rev. **19**, 357-364, 1957/58 (No. 12).

2627: E. G. Dorgelo: Über die Verwendung von Oszillatortrioden in HF-Generatoren mit wechselnder Belastung (Elektron. Rundschau **12**, 241-247, 1958, No. 7). (On the use of oscillator triodes in H.F. generators with varying load resistance; in German.)

This article discusses a problem that arises when the load of an oscillating triode varies. The working line (the locus of all grid voltage - anode voltage combinations occurring in one period) is then displaced with respect to the characteristics, and it is interesting to examine how the H.F. power then changes. From an analysis in which the characteristics are idealized to make them mathematically definable, it is deduced what measures should be taken in the design of a tube to ensure that the delivered power varies as little as possible as a result of load changes. As an example of a "constant power" valve, the triode TB 5/2500 is mentioned. See also Philips tech. Rev. **20**, 299-304, 1958/59 (No. 10).

2628: U. Enz: Relation between disaccommodation and magnetic properties of manganese-ferrous ferrite (Physica **24**, 609-624, 1958, No. 7).

Initial permeability, crystalline anisotropy and magnetostriction have been measured on a single crystal of manganese-ferrous ferrite. The initial permeability shows a high disaccommodation, i.e. a decrease with time. This decrease can be as high as 95% of the value immediately after demagnetization. Disaccommodation is a time-dependent blocking of domain walls, the cause of which is supposed to be a transition of electrons between different ions. The blocked walls cause constricted minor hysteresis loops which indeed have been found. Manganese-ferrous ferrites have in general an extra peak of the permeability as a function of temperature, not hitherto explained. It is shown that this is an effect of disaccommodation.

2629: M. Koedam: Sputtering of a polycrystalline silver surface bombarded with monoenergetic argon ions of low energy (40-240 eV) (Physica **24**, 692-694, 1958, No. 8).

Experimental investigation of the yield of silver atoms sputtered from an electrode bombarded with Ar^+ ions. The sputtering yield is a monotonic function of the ion energy for ion energies of 40-240 eV, showing no threshold value within this range. Extrapolation to 300 eV gives a yield of 2.3 which agrees reasonably well with Keywell's value of 3.0. Similar results have been obtained with Kr^+ ions on Ag.

2630: G. Diemer and A. J. van der Houven van Oordt: Nature of blue edge emission in CdS (Physica **24**, 707-708, 1958, No. 8).

Report of measurements of the intensity dependence of blue emission lines from CdS under excitation from a filtered mercury lamp. For excitation in the region of 4000 Å the fluorescent intensity does not depend significantly on the wavelength. The fluorescent intensity depends on the excitation intensity according to about the 1.5-th power of the latter. From these and previous results the following conclusions can be drawn: 1) Free charge-carrier concentrations must play a role in determining the non-monomolecular recombination law. 2) The green emission can neither be a direct exciton annihilation nor an annihilation of free electron-hole pairs via an exciton state. 3) The blue emission could be due to the recombination of a free electron-hole pair via an exciton state. 4) It is improbable that excitons are generated directly by the exciting quanta (Hg lines in the region of 4000 Å). Free charge-carriers, however, will be formed easily.

2631: W. J. Oosterkamp: Further instrumental developments in cineradiography (Brit. J. Radiol. **31**, 507-510, 1958; No. 369).

Brief description of a cinefluorographic unit based on the Philips 11″ image intensifier tube (for a full description see Philips tech. Rev. **20**, 331-345, 1958/59, No. 11), and a more detailed discussion of "electronic image harmonization", a method of increasing boundary contrast but reducing the contrast range in copies of radiographic films.

2632: H. C. Hamaker: Statistiek en experiment (Statistica neerl. **12**, 119-130, 1958, No. 3). (Statistics and experimentation; in Dutch.)

After a brief survey of the general importance of the statistical design of experiments, two particular examples are discussed in detail, one dealing with a series of 7 simple experiments on the proper conditions for the production of swaged joints, the other being a 3 × 3 × 3 experiment on emission in radio valves. These examples provide illustrative material for some problems of a general nature, to which little attention is paid in textbooks on the subject. One of the secrets of successful experimentation lies in making a proper choice of those factors which should go into an experiment. A series of simple two — or three — factor experiments is often better than one complex design. Analysis of variance is not always needed; frequently too, textbook methods of analysis do not apply and the experimenter should be trained in recognizing such situations. The paper ends with some general conclusions concerning the present and future status of statistics as an integral part of experimental science.

2633: M. J. Sparnaay: Measurements of attractive forces between flat plates (Physica **24**, 751-764, 1958, No. 9).

Results of experiments concerning attractive forces between flat metal plates, and a description of the apparatus used, are given. The observed attractions do not contradict Casimir's theoretical prediction. An explanation of results of earlier measurements made by the author on the attraction between clean, and also between silvered glass and quartz plates, all done in an ionized atmosphere, is suggested. These results were due to differences in the surface potentials of the opposing plates.

2634: J. C. van Vessem: The transistor, seen from within (T. Ned. Radiogenootschap **23**, 177-194, 1958, No. 4).

After the first few hectic years of transistor development, the alloy technique has found the most widespread use in transistor production. The natural limits of this "classical" process are discussed in relation to audio, R.F. and power application. The author describes the later improvements upon this technique resulting from the introduction of other methods, and devotes special attention to transistors for higher frequencies and high power. A review is also given of the relationship between physical design parameters and electrical parameters.

2635: J. H. Stuy: The nucleic acids of Bacillus cereus (J. Bacteriol. **76**, 179-184, 1958, No. 2).

The ribonucleic acid and deoxyribonucleic acid contents of four strains of Bacillus cereus and of various stages in the life cycle of B. cereus strain p2 have been determined chromatographically. The base composition of both nucleic acids was the same for all cells investigated. The results were in agreement with those obtained by means of the orcinol and diphenylamine reactions. During spore germination there was no formation of the nucleic acids. Synthesis of these acids, and of other cell materials as well, began upon incubation of the germinated spores in a growth medium.

2636: H. F. L. Schöler and J. H. Gaarenstroom: The effect of BZ 55 on the pancreatic islets (Acta endocrinol. **29**, 147-159, 1958, No. 1).

In normal subjects and in experimental animals BZ 55 lowers the blood sugar level (Achelis et al., 1955, and many others) and is therefore used for this purpose in diabetes. There is no agreement as to the mechanism of action of BZ 55. In the hope of throwing more light on this mechanism, the effect of prolonged treatment with BZ 55 on the blood sugar level and the histology of the pancreas was investigated. For comparison other substances were used which are known 1) to damage the β-cells of the islets of Langerhans, 2) to inactivate the β-cells and 3) to stimulate the β-cells.

2637: H. Bremmer: Applications of operational calculus to ground-wave propagation, particularly for long waves (I.R.E. Trans. **AP-6**, 267-272, 1958, No. 3).

All results of conventional approximative diffraction theory dealing with the propagation of radio waves around a smooth spherical earth (surrounded by a homogeneous atmosphere) can be derived from a one-dimensional integral equation originally discussed by Hufford. This equation can be solved with the aid of operational calculus which leads, first of all, to the well-known residue series. In this treatment the Sommerfeld theory for a flat earth appears at once as a limiting case; moreover, analytic expressions for correction terms accounting for the finite value of the earth's radius are easily determined. Finally, the equation in question can also be used for the extension to inhomogeneous soil conditions, without neglecting the earth's curvature.

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